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BIOLOGY OF THE SOUTHWESTERN PINE BEETLE
DENDROCTONUS BARBERI Hopk.

1956-1957 STUDIES

(PROGRESS REPORT)

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Entomologist

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INTRODUCTION

The southwestern pine beetle (Dendroctonus barberi Hopk.), a native of the Southwest, is one of the most serious pests of ponderosa pine in the region. It is directly associated with approximately 60 percent of the total annual loss caused by insects in the ponderosa pine type. A large portion of the loss occurs in the fringe type of the host species. Losses caused by the insect in association with D. convexifrons and Ips spp. have been steadily increasing throughout the region. In 1952 an estimated 100 million board-feet of ponderosa pine was killed by this insect and associated bark beetles. By 1956 the losses had increased to approximately 500 million board-feet. Even greater losses are expected for 1957. The studies were initiated in 1956 at Bandelier National Monument and continued through 1957. Figure 1 shows ponderosa pine killed at Bandelier National Monument by the southwestern pine beetle.

DISTRIBUTION

The southwestern pine beetle is native to Arizona, New Mexico, and southern parts of California, Nevada, Utah, Colorado, and to northern ~~New~~ Mexico and the Big Bend of Texas.

1/ The writer wishes to acknowledge the assistance of Barry Pullen and Donald Pierce.

HOSTS

The primary host is Pinus ponderosa Laws. In 1909 Hopkins recorded it as rarely occurring in Pinus edulis Engelm. and Pseudotsugae menziesii var. glauca (Beissn.) Franco. 2/.

DESCRIPTION OF STAGES

The life stages of the southwestern pine beetle, except the egg, are shown in figure 2. The work is readily identified from the egg gallery pattern (figure 5).

The eggs are oblong and pearly white, similar in shape and color to those of other species of Dendroctonus.

The larva is a compact cylindrical legless grub with many transverse folds and wrinkles. The mature larva is approximately 1/4-inch long.

The pupa is creamy white. The wings, legs and antennae of the adult are visible through the pupal skin and when nearly mature the light brown color of the adult becomes apparent.

In 1909, Hopkins described the adult beetle as follows: Type of species, female: Length, 4.5 mm.; very dark brown. Elytra and elytral declivity without long hairs. Head with front convex with slight elevation each side of a faint median groove. Elytral rugosities moderately coarse and dense; striae distinctly impressed. Pronotum with a few long hairs on the anterior half of the lateral area, the remaining area with very fine short pubescence.

"Male type: Length, 4 mm. Front with prominent tubercles each side of a distinct groove. Pronotum without transverse ridge across the anterior area but with a broad transverse impression. The elytral declivity shining with striae punctures distinct and interspaces slightly more rugose than in female."

2/ Hopkins, A. D. The Genus Dendroctonus. USDA Bur. Ent. Tech. Series No. 17, Part 1. June 1909.

There are more females than males. Of a total of 4,228 beetles examined, 2,310 were females and 1,918 were males. Figure 3 shows the frons variation of the male and female beetles.

TAXONOMIC RELATIONSHIPS

The southwestern pine beetle is closely related to Dendroctonus brevicomis Lec., D. frontalis Zimm., D. arizonicus Hopk. and D. mexicanus Hopk. It is distinguished from each by elytral and elytral declivity characteristics.

METHODS OF STUDY

To determine the period of emergence and to obtain information on parasites, predators and associates, trees were caged 1 to 2 weeks after the attack throughout the summer months. Insects were collected weekly from the cages during the field season.

Emergence of adults

The cages made of No. 16 mesh screen and varied in size from 1 1/2- to 2-feet wide to 3 1/2- to 4-feet long. Strips of bark approximately 2 1/2 inches wide were peeled from the tree and the edges of the wire were fastened against the wood with roofing nails (figure 4). The lower part of the screening was funnel shaped, opening into a pint Mason jar.

To determine the period of attack, 4 sample plots were established in the study area in early April 1957. The plots were cruised at weekly intervals; each newly attacked tree was blazed and numbered. One of the plots was later abandoned.

The rate of brood development was determined by following beetle progress in individual trees from the time of attack to emergence of the adult insects.

A pilot control test was initiated at Bandelier National Monument to determine the effectiveness of DDT in repelling attacks of D. barberi.

LIFE HISTORY

Attack Period

The number of trees attacked on the three plots and the dates of marking are shown in table 1. It is possible, by the method used, that actual marking may have occurred a maximum of 6 days after the initial attack.

The attack started the middle of April and continued into September, with peaks the first part of June and the latter half of July.

General observations indicate that the attack period in 1956 was similar except that attacks continued well into October because of the considerably warmer fall.

A total of 22 cages were attached to trees in 1956. They covered a bark area of 128.79 square feet. Only approximate dates of attack are known for the 1956 ~~caged~~ trees. Beetle emergence from these trees is ~~summarized~~ in table 2.

The peak emergence from trees attacked the latter part of April and the first part of May 1956 occurred at the end of June and the first of July. Peak emergence from trees attacked in July occurred the first two weeks in September. Emergence from trees attacked in September 1956 started in April 1957 with peak emergence the last part of May and the first part of June. In all likelihood, initial emergence of beetles from September-attacked trees was by parent adults, since the brood overwintered as larvae and pupae.

Table 1.--Number of trees attacked by the southwestern pine beetle at Bandelier National Monument, 1957.

<u>Date of Examination</u>	<u>Plot 1</u>	<u>Plot 2</u>	<u>Plot 3</u>	<u>Total</u>
April 19	0	0	4	4
25	0	0	1	1
May 1	0	1	1	2
8	0	0	1	1
17	0	0	0	0
23	0	5	0	5
31	1	1	0	2
June 7	1	1	5	7
14	2	3	9	14
21	3	2	4	9
28	2	1	5	8
July 5	4	0	1	5
12	3	5	5	13
19	2	0	9	11
26	2	3	30	35
Aug. 2	1	4	17	22
9	3	3	3	9
16	3	5	2	10
23	2	0	2	4
30	1	0	1	3
Sept. 6	0	0	1	1

Table 2.--Number of southwestern pine beetles collected from
cages on trees infested in 1956. Bandelier National
Monument

<u>Date Tree Infested</u>	<u>Date of Collection</u>	<u>Number beetles</u>
Late April - early May 1956	June 15, 1956	56
	25	172
	July 2	726
	9	780
	17	279
	23	35
	31	8
	Aug. 7	0
	14	1
	28	7
	Sept. 5	0
July 1956	Aug. 14	11
	28	186
	Sept. 5	477
	12	900
	19	688
	26	248
	Oct. 2	170
	9	127
	23	89
	June 18, 1957	61
	July 3, 1957	3
Sept. 1956	April 18, 1957	19
	24	20
	May 1	11
	8	71
	17	100
	23	525
	31	1,030
	June 7	1,128
	14	372
	20	213
	27	135
	July 3	31
	11	13
	18	2
	25	2
	Aug. 1	3
	8	0
	15	1

Peak emergence of beetles from one tree attacked the first 2 weeks in August occurred October 9-23, 1956, with a second peak the last week in May 1957. The studies indicate that emergence continued into 1957, when the trees were attacked after August 1, 1956.

In 1957 another series of cages were placed on trees. The study during 1957 differed in that exact dates of attack were known. A total of 21 trees were caged, 15 of which were used in the emergence study. The cages covered a bark area of 121.69 square feet. Table 3 summarizes the beetle emergence from trees attacked in 1957.

Peak beetle emergence in 1957 from trees attacked from May 23 to June 7 was the last 2 weeks in July. Peak beetle emergence from trees attacked the last of July was the middle part of September. Emergence from these trees was not completed at the close of the field season. Most of the beetles in these trees will overwinter as adults.

Beetles were sexed as they emerged to determine whether there was a preponderance of one sex in early emergence. Emergence was at the same approximate ratio as the sex ratio, 55 percent were females, 45 percent were males.

Parent Adult Emergence

Many adults reemerge shortly after making their egg galleries. In 1957 from a total emergence of approximately 5,100 beetles, 13.7 percent were parent adults. The habits of reemerging adults are unknown. A preponderance of first emerging parent adults are males; later emerging beetles were mostly females.

Table 3.--Number of southwestern pine beetles collected from cages on trees infested in 1957

<u>Date Tree Infested</u>	<u>Date of Collection,</u>	<u>Number Beetles</u>
May 23 to June 7	June 14, 1957	5
	20	36
	27	118
	July 3, 1957	95
	11	38
	18	636
	25	1,096
	Aug. 1, 1957	840
	8	599
	15	265
	22	66
	29	18
	Sept. 5, 1957	6
	13	0
	19	0
	26	3
	Oct. 3, 1957	3
	15	1
July 15 to August 1	Aug. 1, 1957	7
	8	79
	15	214
	22	129
	29	18
	Sept. 5	116
	13	181
	19	322
	26	221
	Oct. 3	78
	15	15

The data obtained from the caging and plot studies indicate that the southwestern pine beetle has three generations a year in fringe type ponderosa pine. During the winter of 1956-57 the insect overwintered as larvae and pupae. The overwintering immature forms of the insect emerged as adults the latter part of May and the first part of June. The progeny of beetles from trees infested the latter part of May and the first part of June emerged the last part of July and early August. Adults resulting from this flight of beetles started to emerge the middle of September. However, emergence was not complete with the onset of cold weather.

DESCRIPTION OF GALLERIES AND CHARACTERISTICS OF INFESTED TREES

Galleries of the southwestern pine beetle are similar to those of the western pine beetle. The egg galleries have a characteristic winding pattern, are non-directional and net-like in appearance (fig. 5). They are constructed for the most part in the phloem but slightly groove the wood. The larval galleries spread out from the egg gallery into the phloem and outer bark. There is little evidence of larval galleries on the inner surface of the phloem and the outer surface of the wood.

Total lengths of egg gallery were measured within the caged area on 12 trees caged in 1956. The greatest total gallery length was 998 inches on 5.55 square feet of bark. The minimum was 282 inches on 6.08 square feet. The average was 104.45 inches of gallery per square feet of bark.

Infested trees at ~~Bandelier~~ National Monument are characteristic in appearance. Upper stems were initially infested by the Arizona five-spined ips, Ips lecontei, Sw., resulting in the fading of the foliage on the upper 1/3 to 2/3 of the tree. The lower portion of the bole is subsequently attacked by the southwestern pine beetle with a consequent

fading of the lower branches. Infested trees turn a brick-red within 6 weeks to 2 months after the initial Ips attack.

Ten trees were measured in the study to determine the proportion of stem attacked by each beetle. The average length of stem, invariably the upper part infested with Arizona five-spined ips was 24.0 feet; the average length attacked by southwestern pine beetle was 22.3 feet. Observations indicate that the southwestern pine beetle prefers trees larger than 12 inches d.b.h. Trees of small diameter were usually infested with the Arizona five-spined ips and the western six-spined ips, or both.

BROOD DEVELOPMENT

The spring and summer generations are complete in approximately 2 months. The fall and overwintering generation requires approximately 8 months for completion.

Eggs

The eggs are laid in the phloem. As the female extends the gallery, she makes small niches on either side and deposits an egg in each. The niche is then packed with frass. Eggs were counted in 240 inches of gallery. The average number of eggs per inch was 5.75; the maximum, 8.6. The incubation period is dependent on temperatures. Observations indicate that during the summer months the eggs hatch in 7 to 10 days.

Larvae

As development proceeds the larvae feed towards the outer bark surface. Larvae may be found immediately next to the outer bark scales in thin-barked trees. Observations on individual trees marked for the specific purpose of determining rate of larval development during the summer months revealed that this stage extends over a period of 3 to 4 weeks. The larval stage of the overwintering generation may extend through a period of 7 months.

Pupae

Mature larvae form a chamber in the outer bark in which to pupate. The time required for the pupae to develop into callow adults during the summer months is approximately 1 week. When the beetle enters the winter in the pupal stage, several months may be required.

NATURAL MORTALITY

Emergence records from approximately 160 square feet of bark surface indicate that 87 percent of the brood dies between the time the eggs are laid until the adult emerges. This mortality figure was obtained by comparing the average number of eggs laid (590) per square foot of gallery with the average numbers of beetles (72) emerging per square foot. The heavy mortality may be due to parasites, predators, sterile eggs, or other causes.

PARASITES AND PREDATORS

Several parasites and predators of the southwestern pine beetle have been identified. Little is known about their effect on beetle populations.

Woodpeckers are important predators. Their feeding is largely confined to the winter months. It is thought that their food during the summer is made up of more easily obtainable insects.

Temnochila virescens (Mann.) (Ostomidae) is the most important predaceous insect. Larvae of this insect feed upon the immature stages of the southwestern pine beetle throughout the summer months.

Several hymenopterous parasites were collected from caged trees in the study area. The most important were:

Roctrocerus eccoptogastri (Ratz.)

Roctrocerus xylophagorum (Ratz.)

Chorebus sp.

Euchalcidia sp.

Hockeria sp.

Aphelenchulus barberus Massey, a nematode parasite of the southwestern pine beetle, infested approximately 3 percent of the population. A total of 346 beetles were examined from 14 trees, 10 beetles were infested. The effect of the parasite on its host is not known.

ASSOCIATED INSECTS

Insects collected from cages were identified by specialists of the Insect Identification Section, Entomology Research Division, ARS.

Several species of Scolytid beetles associated with the southwestern pine beetle were: Ips lecontei Sw., I. ponderosae Sw., I. oregoni (Eichh.), Dendroctonus valens Lec., D. convexifrons Hopk., D. approximatus Dz., Orthotomicus ornatus Sw., Gnathotrichus denticulatus Blkm., Kyleborus scopulorum Hopk., and Pityophthorus spp. I. ponderosae was the most abundant species. In many trees which were initially infested by southwestern pine beetle, subsequent infestations of I. ponderosae eliminated the D. barberi brood.

A complete list of the insects which have been identified to date as associates of the southwestern pine beetle follows. Many may be predaceous or parasitic.

Insects Collected from Cages

Acarina:

Acaridae (traveling forms)
Uropodidae

Hemiptera:

Anthocoridae
Scoloposcellis mississippiensis, Drake and Harris

Coleoptera:

Staphylinidae (Several spp. No specialist available for identification).

Melandryidae

Rushia sp.
Rushia brevicollis (Fall)

Malachiidae

Attalus sp. prob. morulus

Cleridae

Clerinae

Rhizophagidae

Rhizophagus sp.

Histeridae

Plegaderus sp.

Platysoma sp.

Ostomidae

Temnochila virescens (Mann.)

Tenebrioides sp.

Tenebrionidae

Tribolium prob. madens (Charpentier)

Corticeus sp.

Metopoloba sp.

Nitidulidae

Soronia guttulata Lec.

Othniidae

Othnius sp.

Colydiidae

Lasconotus concavus Casey (or near)

Dasytidae

Trichochrous sp.

Anthicidae

Notoxus sp.

Cerambycidae

Arhopalus sp. prob. montanus Lec.

Acanthocinus obliquus Lec.

Poliaenus sp. prob. negundo (Schffr.)

Curculionidae

Cylindrocopturus sp.

Cossonus sp. prob. crenatus Horn.

Cimbocera conspera Fall.

Lechriops californicus (Lec.)

Zascelis prob. inorata Lec.

Rhyncolus nimius Csy.

Brachrhininae Unknown.

Tomolips sp.

Scolytidae

Orthotomicus ornatus Sw.
Ips lecontei Sw.
Ips ponderosae Sw.
Ips oregoni (Eichh.)
Ips sp.
Pityophthorus sp.
Gnathotrichus denticulatus Blkm.
Xyleborus scopulorum Hopk.
Dendroctonus convexifrons Hopk.
Dendroctonus approximatus Dz.
Dendroctonus valens Lec.

Hymenoptera:

Formicidae

Campanotus sp.
Campanotus vicinus Mayr.
Liometopum occidentale luctuosom Whlr.
Tapinoma sessile (Say)
Monomorium minimum (Buckl.)

Pteromalidae

Roptrocercus sp.
Roptrocercus eccoptogastri Ratz.
Roptrocercus xylophagorum Ratz.

Chalcididae

Euchalcidia sp.
Hockeria sp.

Braconidae

Chorebus sp. (parasite of diptera)

Encyrtidae

Metopoloba sp.

Eulophidae

Tetrastichus melanis (parasite of coccinelids)

Pompilidae

Pompilus parvulus Bks. (parasite of spiders)

Ichneumonidae

Campoplegni (genus and sp. unknown)

CHEMICAL CONTROL

Research studies on the control of the southwestern pine beetle are centered around biological and cultural methods of control. At times, however, it may be necessary to control infestations by other methods, especially in areas of high recreational use.

During the summer of 1957 it was urgent that green ponderosa pine be protected from attacks of the southwestern pine beetle and the Arizona five-spined ips in the headquarters and camp ground areas of Bandelier National Monument. In a pilot control test, Park Service employees treated 745 green trees with a 2 percent emulsion of DDT. One application was made at the end of May, one application during the middle of July; 286 trees in the areas were left untreated. In September after beetle flight had ceased, 103 of the check trees had been killed by the beetles; only 3 of the treated trees were killed.

SUMMARY

The southwestern pine beetle, Dendroctonus barberi Hopk. is directly associated with 60 percent of the total annual insect-caused losses in the ponderosa pine type of Arizona and New Mexico. The insect had 3 generations in the fringe type ponderosa pine at Bandelier National Monument in 1957. The beetle flies and attacks green trees from the first part of May to October. In 1957, however, the most intense period of attack was during the latter part of July and the first part of August. In 1956 when temperatures were abnormally high, the attack extended into November.

Approximately 13 percent of the total emergence during 1957 was parent adults. The habits of the reemerging adults are not known.

The galleries are similar to those of the western pine beetle. The beetle invariably attacked the lower parts of the bole of its host after the tops had been killed by the Arizona five-spined ips.

During the summer months, development of the beetle from egg through the adult stage requires 50 to 60 days.

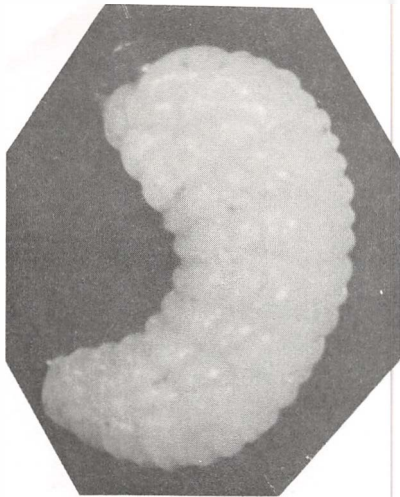
Temnochila virescens is the most important predator of the beetle.

Woodpeckers consume large numbers of the insect only during the winter months.

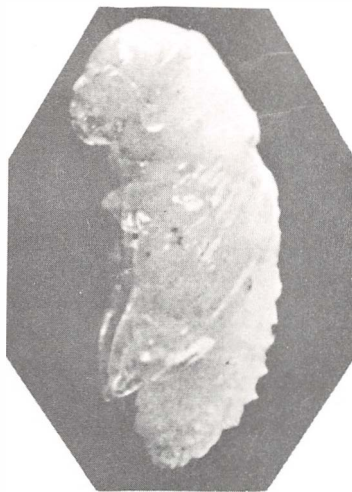
A 2 percent emulsion of DDT was found to be effective in protecting green ponderosa pine against attacks of the beetle.



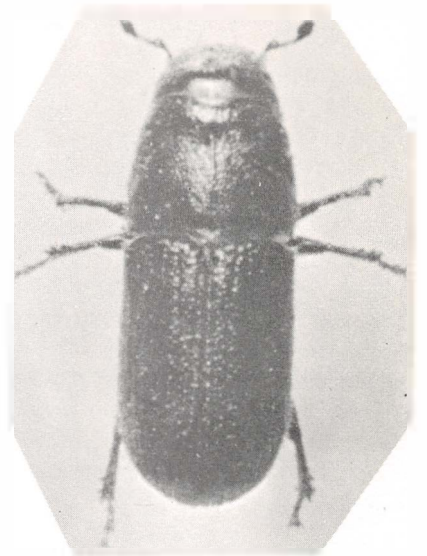
Figure 1.--Ponderosa pine stand killed by the Arizona five-spined ips and the southwestern pine beetle at Bandelier National Monument.



Larva



Pupa

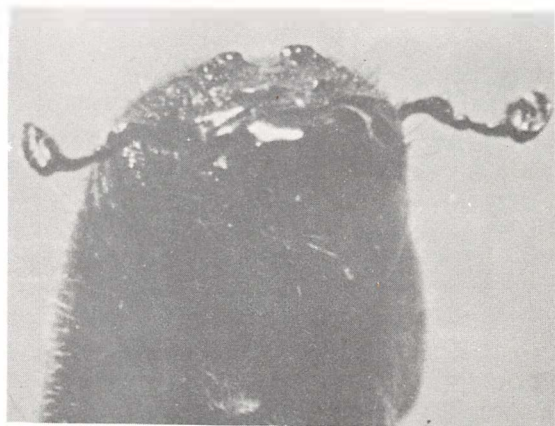


Adult

Figure 2.--Life stages of the southwestern pine beetle. Greatly enlarged.



Female



Male

Figure 3.--Frons variation female and male southwestern pine beetle.



Figure 4.--Tree cage used in emergence studies of the southwestern pine beetle.

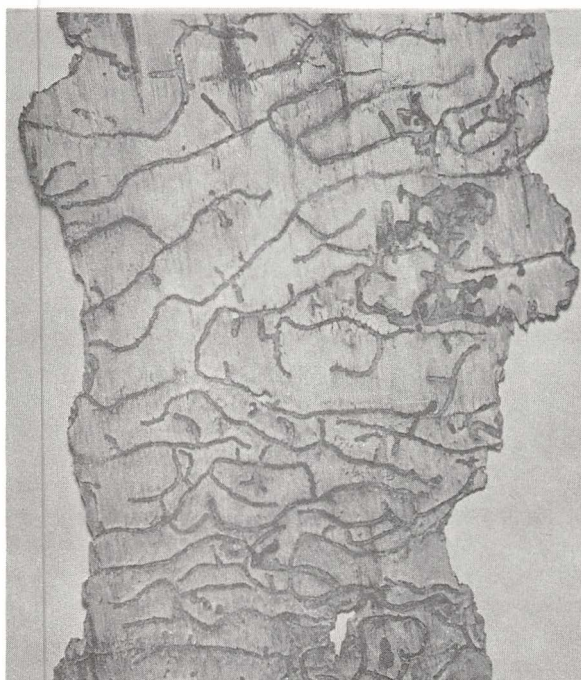


Figure 5. Galleries of the southwestern pine beetle.